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CONTINENTAL MARGIN DATA COLLECTION

PILOT PROJECT

A Division of Research and Development
Open-File Report (CT-02-69-45)
Bureau of Solid Waste Management
by Sonja Schuyler and George Heimerdinger
of the National Oceanographic Data Center

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Environmental Health Service
Bureau of Solid Waste Management
1970

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INTRODUCTION

The interest shown by coastal metropolitan centers in the disposal of waste materials on the U. S. continental margins has initiated action by several Federal agencies to determine the information available concerning U. S. coastal waters. The Bureau of Solid Waste Management, Department of Health, Education, and Welfare, proposed to the National Oceanographic Data Center (NODC) that a study be conducted to determine the amount and availability of oceanographic data for the continental margins of the United States and also to summarize or display the oceanographic data in a form that could be used by the Bureau for quick reference purposes. The ultimate objective is to be able to answer, on short notice, the questions as to whether a particular area is suitable for disposal of solid waste; or, if available data are insufficient to respond to such a question, what additional information is required? A pilot study conducted on a small oceanic area was considered as a better method than an investigation of the entire continental margin. As part of the pilot project, an indexing system was suggested for retrieval of data and information by geographic area and subject type. This report discusses the pilot study program and its results after 6 months of effort.

The pilot study was intended to determine:

1. If data and information could be collected, cataloged by subject and area, and effectively retrieved from the indexing system selected for the project.

2. The yearly funding required for a 4- to 5-year data acquisition program and file maintenance which would provide a basic data bank covering the Atlantic, Gulf and Pacific continental margins.

3. The various types of products (data summaries, location plots, etc.) that NODC could provide the Bureau of Solid Waste Management for reference purposes.

The pilot study areas were suggested by the Bureau: one off the southern California coast, and the other off the New Jersey-Delaware coast. The exact geographic boundaries were: East Coast, 38°-40° N and 72°-74° W; West Coast, 32° 40'-34° N and 117° 15'-119° W, and seaward of the 50-meter contour interval. However, in the search for data these geographic boundaries were not rigidly adhered to so that valuable work outside the areas would not be overlooked.

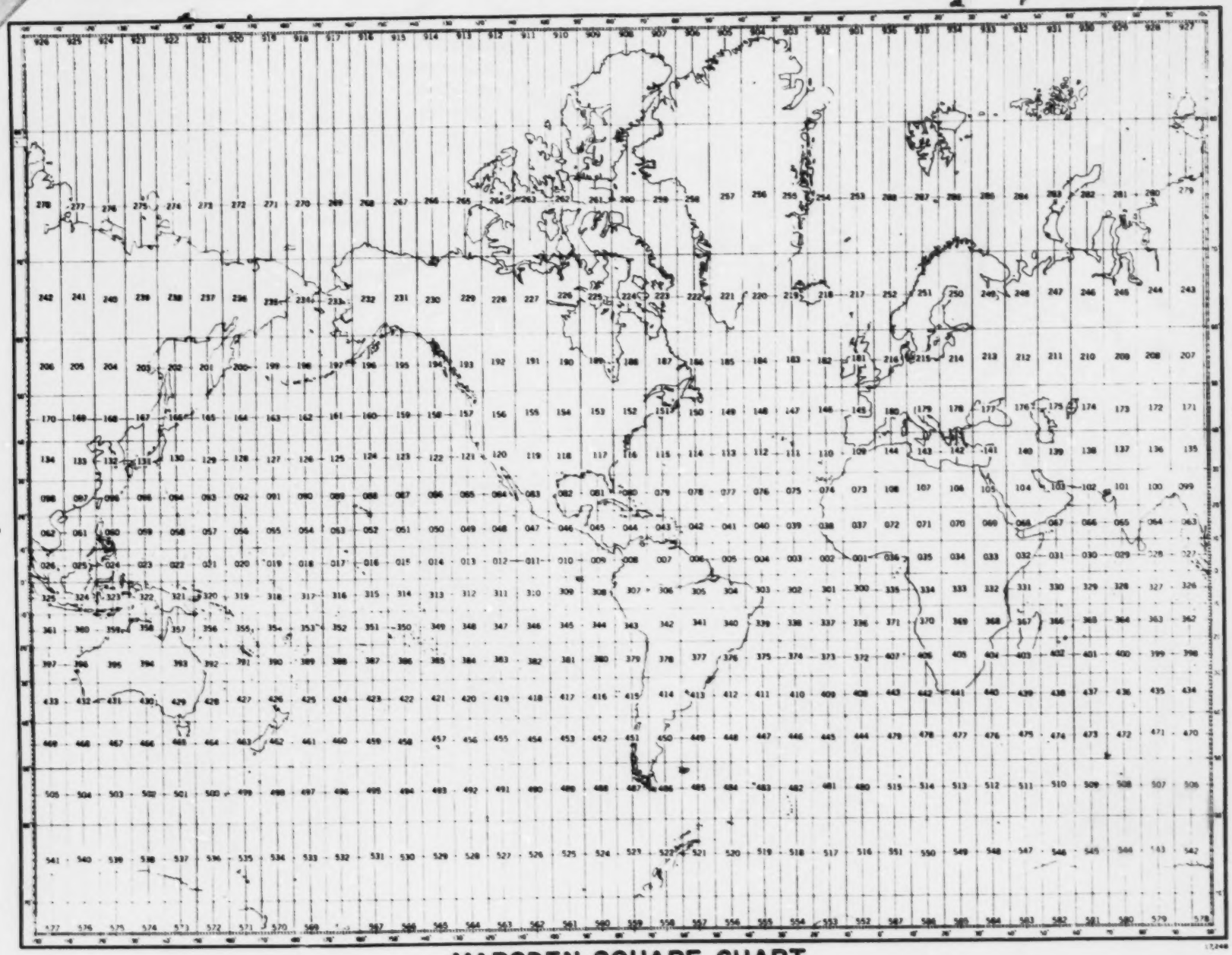
The data/information storage and retrieval system uses coordinate indexing by two categories: geographic area and subjects. Incoming data are read by oceanographers and indexed by appropriate terms from each of the above categories. The geographic

area is defined by Marsden square (see figure 1), one-degree square, and quadrant of a one-degree square. The subject terms are listed below:

Area	Remarks
West Coast	These terms are used in cases where documents summarize data over a large geographic area or do not give specific locations for samples or observations.
Gulf Coast	
East Coast	

Biology	Remarks
Bacteriology	
Benthos	
Nekton	
Plankton	
Marine Borers	
Fouling	
Corrosion	
Control Tests	
Materials Tested	Open list of materials.
Commercial Fishing	Commercial harvesting of marine organisms.

Geology	Remarks
Bathymetry	
Bottom Photography	Includes television.
Sediment Description	Sample described without the aid of laboratory analyses.



MARSDEN SQUARE CHART

FIGURE-1

Geology (cont.)	Remarks
Sediment Analysis	Sample analyzed in the laboratory.
Sediment Transport	
Sedimentation Rates	
Underwater Observations	Observations made by divers and from submersibles.
Commercial Mineral Resources	

Pollution Studies

Physical Oceanography	Remarks
Surface Currents	
Subsurface Currents	
Bottom Currents	
Vertical Current Profiles	
Water Column Characteristics	

Various data collection methods have been tried, but generally library searches and personal contacts were the most useful. Letters were sent to individuals in industry, Government (Federal and State), and research institutions, who could be expected to aid in data collection. These letters received careful attention and thus encouraged continuation of this approach. Also, the Data Center's liaison representatives in San Diego, California, and Woods Hole, Massachusetts, were extremely helpful because of their local knowledge and personal contacts. They will continue to be an essential part of NODC's data acquisition program.

The following summary reports for the pilot study areas will point out only the larger or more important data collections. A more complete bibliographic list appears as Appendixes A, B and C to this report. Since the authors' knowledge of the existing historical data and oceanographic investigations underway is far from complete, additional sources of data and information will be added to the data bank for these two areas.

EAST COAST PILOT STUDY AREA

This area (see figure 2) includes portions of the continental shelf and slope, with the shelf break bisecting the area from the northeast to southwest into zones of shallow and deep-water. Depths in the southeastern portion exceed 2,000 meters. Along the shelf break, the continental shelf and slope are deeply cut by numerous canyons postulated as the remnants of river cutting during periods of lowered sea level. The Hudson, Wilmington, and Baltimore Canyons are the major relief features in the study area. Data are concentrated landward of the shelf break and around the above mentioned canyons.

Several authorized explosive dumping sites are located in the deep-water portion of the survey area. The Atomic Energy Commission used the site centered at 38° 35.5' N and 072° 09.5' W for disposal of low-level, packaged, radioactive waste. In October 1961, an environmental survey of the dump site, conducted by the U. S. Coast and Geodetic Survey, produced indications of possible leakage of radioactive materials from the containers (Coast and Geodetic Survey, 1961). This is the only known pollution investigation conducted in the pilot area.

However, intensive work has been carried out to the north of this area in connection with a sewage sludge-acid waste disposal site. The results of work by the Bureau of Sport Fisheries and Wildlife Laboratory, Sandy Hook, New Jersey, in the past year revealed a 50 to 70 kilometer-square area of impoverished bottom fauna along with seabed drifter recoveries indicating a strong movement of bottom water from the waste disposal area to the Long Island, New York, beaches. A 30-percent reduction in zooplankton abundance was noted in the dumping area, compared with samples taken outside the area. Coring of the disposal area showed sludge accumulation or mixing with the sediments to a depth of 0.3 to 1 meter (Sandy Hook Marine Laboratory, 1969). Although located outside of the pilot study area, the sludge-acid dump site experiences the same oceanic and meteorologic conditions as the shelf portion of the study area, and the knowledge gained by the work of Sandy Hook can be applied to the pilot area.

A site in shallow water to the west of the pilot area is under study by the University of Delaware and Hydroscience Incorporated for DuPont Corporation as a location for liquid waste disposal. The results from this survey are not yet available (Myers, personal communication).

Several geological investigations which fall in the study area have been made on the continental margin. A systematic surface sediment sampling program for the entire east coast continental shelf and slope, which included sampling on 26 kilometer (10 mile) centers at depths as great as 2,000 meters, has been conducted by Woods Hole

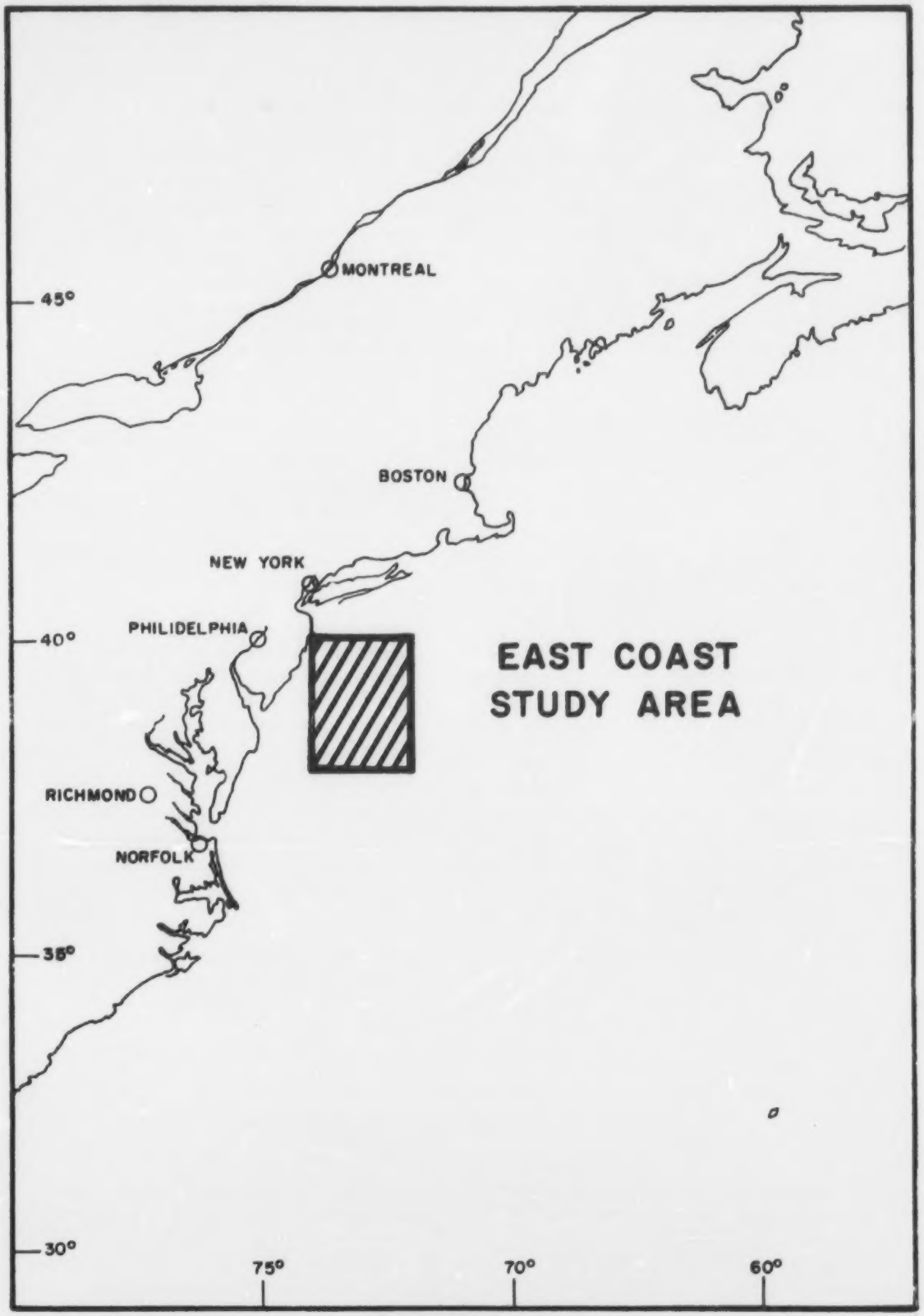

MONTREAL
45°
BOSTON
NEW YORK
PHILIDELPHIA
40°
EAST COAST
STUDY AREA
RICHMOND
NORFOLK
35°
30°
75°
70°
60°

FIGURE-2

Oceanographic Institution and the U. S. Geological Survey (Woods Hole Oceanographic Institution, 1966). As a part of this survey, numerous bottom photographs were taken simultaneously with the bottom samples. Although only a brief sediment description of these samples is presently available, grain size analyses will be soon completed. A portion of these samples was seived for organisms; thus organism counts and biomass values are available (Emery, Merrill, and Trumbull, 1965). The bottom sediment types on the continental shelf from Georges Bank to Delaware Bay were mapped as the result of an earlier sampling investigation (Shepard and Cohee, 1936). Sediment of recent age is reported (Stetson, 1949) to mantle the entire continental slope and canyons from Georges Bank to Norfolk Canyon, except in the canyon and gully walls where Cretaceous and Tertiary formations outcrop. These recent sediments are generally silts of varying textures with occasional areas of clay. Sediment-size analyses were conducted on the samples from both investigations. Stetson also dated the consolidated rock fragments obtained from the canyon walls. Thorough environmental investigations have been made by the U. S. Naval Oceanographic Office (Oser, 1969) on the Hudson Canyon, and the Smithsonian Institution and U. S. Coast Guard (Stanley and Kelling, 1968) on the Wilmington Canyon. On the inshore areas off the New Jersey coast, the Coastal Engineering Research Center, Army Corps of Engineers, has conducted a sand and gravel survey. To the north of the pilot area (Hollister and Korites, 1969) an investigation of the distribution and engineering properties of the surface sediments is being conducted for American Telephone and Telegraph.

Biological data for the study area are largely a result of geological surveys and commercial fishery investigations, rather than comprehensive surveys of the biology of the area. As noted above, the camera-grab survey (Emery, Merrill, and Trumbull, 1965) has provided biomass figures and some dominance patterns for the continental shelf region of the study area. Their data from approximately the upper 30 centimeters indicate that between two-thirds and three-fourths of the benthos are epibenthic and that areas covered by broken shell show the lowest biomass. Bottom photographs and video tape taken by Stanley and Kelling (1968) during their surveys of the Wilmington Canyon provide data on the benthos of the canyon and continental slope which could be compared with the shelf photographs. Since no grab samples were taken, biomass data are not available. Both on the shelf and in the Wilmington Canyon, benthic organisms mark the bottom sediments.

Fishery investigations have produced information on commercially important benthic invertebrates. The shallow waters of the mid-Atlantic shelf support lobster, surf clam, and scallop fisheries.

Also, a deep-water lobster population exists along the edge of the continental shelf, south of Georges Bank. An extensive surf-clam survey by the Bureau of Commercial Fisheries, Exploratory Fishing and Gear Research Base, Gloucester, Massachusetts, has mapped this resource. Exploratory fishing for the red crab, also conducted by the Bureau of Commercial Fisheries, Gloucester, yielded the best catch of their survey from the area 37° 40' N-38° 27' N, 73° 20' W-74° 12' W; but at the time of the survey, the investigators felt that operating costs would prohibit development of this fishery.

Surveys of the fish in this area have been more numerous and more extensive than surveys of the benthic invertebrates. The Bureau of Commercial Fisheries at Woods Hole, Massachusetts, is conducting an ambitious groundfish survey program (Grosslein, 1969) for which they have developed a processing system which can generate catch and weight data, species occurrence data, and can compute length and weight frequency distribution. Sandy Hook Marine Laboratory has a regular sampling program for fish larvae and zooplankton over the continental shelf from New Jersey to Florida, yielding important information on the geographic distribution and seasonal occurrence of larval forms. Records for the menhaden fishery, maintained by the Bureau of Commercial Fisheries, Beaufort, North Carolina, indicate that these fish move into the study area during the summer months and them return to southern waters during the winter.

Few direct subsurface current measurements have been taken in the study area. Measurements made by Oser (1969) in the Hudson Canyon reveal rotary currents on the shelf at a depth of 117 meters with mean current speeds of .19-.23 knots; the measurements made in the canyon by using a manned submersible and dye releases show currents traveling upslope (northwest) at a speed of .12 knots. Measurements made at the bottom of the continental slope at depths of 1,855 and 2,000 meters indicate a dominant southwesterly flow with mean current speeds of .15-.20 knots. Indirect bottom current evidence is available from the underwater photography and television used in numerous locations throughout the study area. Deep-water bottom current measurements at five locations northeast of this area have been made by the University of Rhode Island. NODC is completing work on a bottom drifter and drift bottle file from which drift information can be retrieved by point of release. A surface circulation atlas prepared from drift bottle recoveries is available for the Northeastern United States (Bumpus and Lauzier, 1965). (Appendix A presents the references collected for this study area.)

WEST COAST PILOT STUDY AREA

The phenomenal growth of cities in southern California and the consequent necessity to use the sea for waste disposal have stimulated studies of the offshore waters. Fortunately, the State of California has been foresighted in extending its interest beyond the all too common quick and dirty predisposal survey. The joint efforts of the State Water Quality Control Board and the Allan Hancock Foundation have produced an extensive survey of the area's geological and biological conditions, and the California Cooperative Oceanic Fisheries Investigations program has done the same for the oceanographic aspects. Supplementing this information from these large-scale efforts are the results of specific projects conducted by the many local, State, and Federal agencies located along the southern California coast.

The submarine topography of the southern California study area (see figure 3) is far different from the rather featureless east-coast study area. The coastline of southern California is irregular in shape, with sandy beaches interrupted by numerous rocky headlands, and fronted along its entire length by a very narrow continental shelf. From the shelf break seaward, the continental borderland (Shepard and Emery, 1941) is a series of elongated northwest-southeast-oriented basins and submarine ridges, with scattered shallow banks. The submarine ridges rise in places above the ocean surface to form Catalina and San Clemente Islands. Marine canyons intersect the slopes of the mainland, islands, and submerged banks and terminate at the basin floor in a feature resembling an alluvial fan (Shepard, 1963). The basins act as large sediment traps.

As a result of the sampling by the Allan Hancock Foundation and supplemental research performed by numerous investigators in the areas of the sewage and industrial waste outfalls, it is evident that these discharges affect the benthic population. The organisms which are more pollution-tolerant thrive and multiply in areas enriched by discharged wastes, forcing out the less tolerant individuals. In general, as one moves away from the discharge point, the variety of organisms increases and population density returns to normal (California State Water Quality Control Board, 1965). A 5-year fish-trawl survey in Santa Monica Bay was unable to show that fluctuations in fish abundance were related to waste discharges into the area. However, it suggested that giant kelp have not been able to survive in the affected areas (Carlisle, 1969).

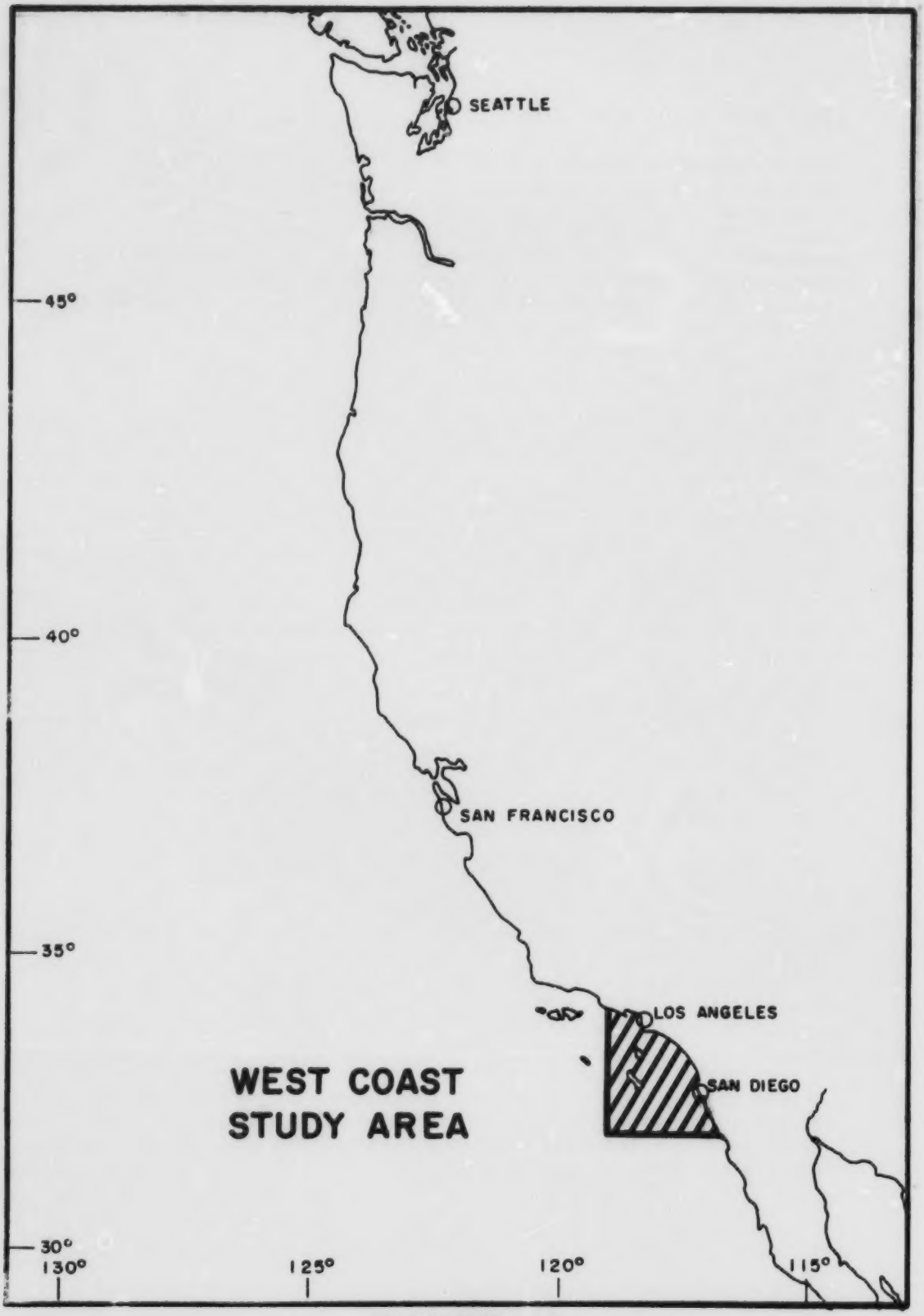

SEATTLE
45°
40°
SAN FRANCISCO
35°
LOS ANGELES
SAN DIEGO
WEST COAST
STUDY AREA
30°
130°
125°
120°
115°

FIGURE - 3

The numerous sewage and industrial waste outfalls in the pilot study area have been constantly monitored by State and county sanitation and water quality control agencies. These data are generally shallow-water observations consisting of temperature, nutrients, phytoplankton, and coliform measurements which are in raw data formats (Love, personal communication).

To the west of the study area, Santa Cruz Basin was picked as a site for disposal of low-level radioactive wastes on the basis of its distance from the mainland and the depth of its floor. After reviewing the environmental data for this basin, the Committee on Oceanography, National Academy of Sciences - National Research Council, recommended that the dump site be switched to the Santa Barbara Basin, which is much shallower and nearer to the mainland. The unlikely return of waste materials from this basin to the continental borderland along with the basin's anaerobic properties, sediment conditions, and sparse population made it a more desirable disposal location (Working Group of the Committee on Oceanography, 1962). This example points out that the deepest hole farthest from shore is not necessarily the best site for the disposal of certain waste materials.

The geology of the shelf and borderland has been discussed in detail in numerous works by Shepard, Emery, and other investigators. The sediments of the continental shelf have been thoroughly mapped as a result of the sampling program conducted by the Allan Hancock Foundation. Sampling of the canyons and basins has not been as extensive as that of the shelf. The general sediment distribution on the shelf grades from coarse to fine toward the shelf break, except around offshore rocky outcrops where complex sediment patterns exist and in areas affected by waste discharge (Jones, 1969). The sediments of the basins are predominantly silty clays, except in the alluvial fan deposits at the base of the canyons where coarse nearshore sands are interbedded with the silty clays of the basin floor. Extensive areas of rock are exposed on the banks, slope, and canyon walls (Shepard, 1963).

Two outstanding generalizations emerge from a review of the biology of the study area: Species diversity is great and their distribution is patchy. The biology of such an area can be best described in terms of its topography, since this is the most easily recognized environmental characteristic. The significant topographic features of the study area are the narrow continental shelf, the precipitous submarine canyons, and the oval offshore basins.

Three recurring benthic animal associations have been identified on the mainland shelf. They are the Northria-Tellina association which ranges from 10-33 meters, the Listriolobus association which ranges from 25-70 meters, and the Amphiodia-Cardita association which ranges from 53-105 meters (Jones, 1969). Water depth and sediment type seem to influence the distribution of these associations.

Both commercial and sport fishermen are active in the mainland shelf waters. The commercially important species are flounder, rockfish, spiny lobster, and pink abalone, and in recent years, the landing of trash fish for use in animal food has also become important. These commercially important species seem to be underexploited (Orcutt, 1969).

The submarine canyons of the study area form transitional environments between the shallow shelf region and the deeper offshore basins and, as such, hold populations typical of both regions. In general, the animal associations vary markedly with depth, and species diversity is greatest at the head of the canyons. Samples taken along the axis of a canyon may show species typical of the shelf or the continental slope, while the biology of the canyon fans resembles that of the associated basins (Hartman, 1963).

The study area encompasses four basins: San Pedro, Santa Monica, Santa Catalina, and San Nicolas. The San Pedro and Santa Monica Basins are the shallowest of the four and are also closest to the continental shelf. These two conditions suggest that these basins would be the most productive; however, the basin sills are at the oxygen minimum depth, so the waters of the basin are practically devoid of oxygen. The basin floors show no evidence of burrowing, and the only signs of life are polychaete tubes and dead scallop shells. In contrast to these two basins, the floors of the Santa Catalina and San Nicolas basins are marked by animal activity, and bottom samples indicate a sizable bottom population. The higher oxygen concentration is responsible for this difference (Hartman and Barnard, 1958). The midwater fishes of the basin region are typical of the three water masses which mix in the area (Lavenberg and Ebeling, 1967).

The continental borderland and shelf of southern California are influenced by an eddy of the California Current System. The most significant factor causing water motion over the shelf is the winds, and as a result the shelf circulation shows a wide variation in velocity. However, the net flow over the shelf is to the southeast (California State Water Quality Control Board, 1965). Drift bottle recoveries confirm the southeast flow over the shelf and also

indicate the existence of a northwest-flowing surface countercurrent (Sverdrup and Fleming, 1941). Extensive deep-water current observations have been made off San Clemente Island by the Navy. They reveal that the currents appear to be affected by the tidal forces and the varied submarine topography. Current speeds of 1.3 knots at 150 meters have been recorded in this area (Oser, Berger and Franc, 1967). Current studies in the canyons and basins by using a manned submersible and dye releases are available from U. S. Naval Research and Development Center, San Diego (Dill, personal communication). Studies on sediment transport in the canyon heads by using SCUBA gear have also been conducted by Dill. (Appendix B presents the references collected for this study area.)

MARINE FOULING AND CORROSION

The problem of fouling and corrosion in deep-water has not received a great deal of attention. Most studies have been conducted in bays and harbors or from piers which extend through the surf zone. Temperature, salinity, turbidity, and dissolved nutrients are the most important environmental conditions which influence fouling and corrosion, and these conditions in near-shore waters differ greatly from those in open ocean waters. For this reason, the results of nearshore studies have little relevance to the problems in open waters.

The Naval Civil Engineering Laboratory, Port Hueneme, has conducted long-term experiments in depths ranging from 720 to 1,720 meters off Santa Rosa Island (Muraoka 1964, 1966, 1968). These studies have shown that corrosion caused by algae can occur as deep as 610 meters (Muraoka, 1968). Also, bacteria have destroyed natural fibers when these fibers were placed in contact with bottom sediments. Some fouling by tube worms has occurred after long exposure, and shipworms have attacked the wood test panels in all experiments (Muraoka, 1964).

A similar deep-water study has not been attempted on the east coast; however, the sampling arrays used by Sandy Hook Marine Laboratory to determine potential production of artifical reefs could also provide information on the degree of fouling in shallow continental shelf waters (Pearce, personal communication). The only information for deeper east coast areas at the present time has come from performance data for deep-moored buoys and moored current meter arrays. Although corrosion appears to be a major cause of mooring failure, failures of the same materials in the same location have occurred after widely differing exposure times (Fofonoff, 1967). While this type of information is valuable, it is a poor substitute for a systematic investigation of the problem. (Appendix C presents the references on fouling and corrosion collected for the pilot study.)

NODC AND OTHER MARINE DATA BANKS

Classical oceanographic and meteorological data, which would be fundamental to any study of an ocean environment, have been collected and stored in large data banks. The National Oceanographic Data Center mainiains such data banks filling the needs of Government, industry, academic and research institutions, and the public by providing an efficient mechanism for processing, exchanging, and storing globally collected marine data and information, and a central location from which marine data and products may be obtained expeditiously and economically.

The Center is funded by a number of Government agencies, each with its own specific interest in the realm of oceanography. An Advisory Board, made up of representatives from the sponsoring agencies, the National Academy of Sciences, and observers from industry and the National Council on Marine Resources and Engineering Development, provides policy and technical direction for NODC.

The key to the Center's ability to meet the needs of its users depends on computer manipulation of oceanographic data and information. An IBM 360/40 computer system provides for high-speed processing, direct-access retrieval, and cathode-ray tube (CRT) display. A data inventory, known as the National Marine Data Inventory (NAMDI), is queried through a computer time-sharing system. Initiated in 1967, this inventory contains information on quantities and types of data, areas of operations, and responsible personnel. Input is received from major U. S. activities contributing to the national marine science effort.

The physical properties and nutrient chemistry data for the water column of the study areas, as well as for the entire continental margin of the United States and its possessions, are stored in the NODC data banks. Various Center-generated computer programs can be used to retrieve, summarize, or plot these data. A temperature atlas (Walford and Wickland, 1968) for the waters of the east coast shelf was prepared by using the combined bathythermograph data banks of NODC and the Woods Hole Oceanographic Institution. Bottom temperature data are being gathered by the Bureau of Commercial Fisheries, Woods Hole, in conjunction with their ground fish surveys. A large collection of bottom drifters and drift bottle observations for the entire east coast is held by Dean Bumpus at the Woods Hole Oceanographic Institution, and the NODC also holds drift data acquired predominantly from his collection. Bottom sediment files exist at the U. S. Naval Oceanographic Office (worldwide), Scripps Institution of Oceanography (Pacific only) and NODC (worldwide); however, there is

extensive duplication in all three files. The Bureau of Commercial Fisheries maintains catch records on commercially fished organisms and conducts extensive coastal water surveys in an attempt to improve the catch of the United States fishing industry. Sea, swell, and surface current files are kept and periodically updated by the U. S. Naval Oceanographic Office. The National Weather Records Center maintains files of various sea surface and near surface meteorological conditions, which are extensive enough to provide synoptic reports. Data from these files can generally be obtained by area and summarized by month, season, or year.

RESULTS AND RECOMMENDATIONS

The pilot study was conducted by a working group of three, two oceanographers and one technician, on a part-time basis. Limited funding prevented full-time involvement in the project. For continued file maintenance and data gathering on the present sites or new locations, funding should be considered for a minimum working group of three individuals on a full-time basis. Funding of $40-45 thousand a year would support a group of this size working continuously along the guide lines stated at the start of the pilot study. The pilot study covered approximately 560 kilometers along the 9,920 kilometer continental margin of the United States. Assuming that these areas have been studied 10 times as intensively as the average continental margin area, the recommended level of funding would result in completing the initial data collection phase in 5 years.

Data acquisition efforts will continue by writing letters to individuals who have data pertinent to the study and by travel to laboratories, institutions, and Federal or State agencies for direct communication with persons engaged in studies of our coastal waters. The authors of this report have established that first-hand information obtained during personal visits keeps them abreast of what is happening in the areas of their interest. In a majority of cases published data reports may appear years after a survey has been conducted. NODC liaison officers are continuously brought up-to-date on the Center's data needs; their personal contacts and local knowledge make them valuable instruments in NODC's data collection efforts.

A continental Margin Data Bank is under serious consideration by the NODC. The geographic area encompassed by this data bank would include the estuarine environment; the seaward limit may be presently defined as the seaward edge of the areas designated by the Bureau of Solid Waste Management. Data acquisition efforts would continue in the areas assigned by the Bureau; however, all data located by these efforts within the geographic limits of the Continental Margin Data Bank would be retained and entered into this system. At the same time, other acquisition mechanisms of the Center would also be contributing data to this system for areas not presently designated by the Bureau. The Continental Margin Data system would have the same retrieval capabilities as the manual system used in the pilot project, with the added advantage of being linked to a computer for rapid retrieval and possible data compilation.

The documents collected for the pilot study presently are not overwhelming in volume; however, after several years they could amount to a small library. For this reason, miniaturization of this file either on microfilm or microfiche should be considered. Microfiche has the advantage over microfilm in that one can more easily interfile with microfiche and retrieve the desired document directly from a file without having to search through a reel of film containing many reports. Also, microfiche can be easily reproduced on in-house equipment.

The type of product NODC can presently furnish the Bureau for reference pruposes is illustrated in Appendixes A, B, and C of this report. Appendixes A and B are arranged by geographic area and subject type. The pilot area is divided into its one-degree squares by the Marsden square, one-degree square numbering system, and the references are listed by subject type for each one degree. The lists are introduced by references which apply to the general coastal area. The present system is so structured that retrieval can be made on a quarter of a one-degree square, but this is not shown in the report. Appendix C contains a listing of sources on fouling and corrosion studies, to illustrate the capability of the system to retrieve data by subject type alone--a type of retrieval which is especially useful when data are lacking for a particular geographic area.

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The number in parenthesis following each bibliographic reference is a document number assigned by the Data Center.

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Appendix A

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This list of references is arranged by geographic area and subject type. The pilot area is divided into its one-degree squares by the Marsden square, one-degree square numbering system, and the references are listed by subject type for each one degree. The list is introduced by references which apply to the general coastal area.

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Appendix B

REFERENCES: WEST COAST PILOT STUDY AREA

This list of references is arranged by geographic area and subject type. The pilot area is divided into its one-degree squares by the Marsden square, one-degree square number system, and the references are listed by subject type for each one degree. The list is introduced by references which apply to the general coastal area.

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Appendix C

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